# EFFECTIVE USE OF AIRCRAFT SIMULATION IN AIRCREW TRAINING

GRADUATE RESEARCH PAPER

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Daren S. Gulbransen

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## Abstract

A decreasing defense budget and the continued high tempo of operations involving the military require careful planning to maintain an effectively trained force. Air Mobility Command (AMC) controls the aircraft that provide transportation support for the DoD. As AMC's fleet decreases in size, training requirements conflict with operational mission taskings. AMC is working to increase its use of aircraft simulation in an effort to provide more of its aircraft for operational taskings without any loss in training opportunities.

This research paper examines AMC's status regarding simulator training for its aircrews. AMC is increasing its use of simulators to conduct aircrew training. Upgraded equipment is allowing for an increased transfer of training from the aircraft to the simulator. Costs in doing this training are being amortized through savings in aircraft flight training time. New technology is providing ways to enhance both aircrew and maintenance personnel training in the future. This new technology includes virtual reality, simulator networking, and unit training devices. AMC must continue to look beyond the standard simulator training programs for new ways to meet its training demands.

# EFFECTIVE USE OF AIRCRAFT SIMULATION IN AIRCREW TRAINING

## I. Introduction

New military strategies have the United States reducing its forward presence abroad. The Department of Defense (DoD) is tasked under this plan to rapidly deploy armed forces to any overseas location. Air Mobility Command (AMC) is the strategic airlift component that is critical to the early arrival of troops and cargo for overseas deployments (GAO, 1994:1). Even though we have seen the end of the Cold War, AMC continually receives taskings that push its people, aircraft, and infrastructure to their limits. This high operations tempo environment, coupled with tightening fiscal constraints, requires thorough planning to maintain an effective force (AMMP-97, 1996: i).

The General Accounting Office (GAO) released a report in September 1994 titled *Strategic Airlift: Further Efforts Can Be Taken to Extend Aircraft Service Life* . The report stems from a request to assess whether current airlift aircraft such as the C-5 and C-141 are being used in a way that conserves our strategic airlift capabilities for wartime taskings.

Worldwide deployment of our armed forces depends heavily on AMC's aging airlift fleet. As the C-17 slowly comes on line and the C-141 is retired from the fleet, AMC must employ its airlift in a manner that extends the life of its current aircraft.

Extending aircraft service life benefits both AMC and its customers by freeing aircraft to be used for operational missions such as joint training exercises, contingency airlift, and wartime deployment support. For these reasons it is imperative that AMC find ways to utilize its current airlift fleet in a manner that will ensure its aircraft are available to answer these demands. The purpose of this paper is to look at various options in the flight simulation arena that AMC is undergoing or can undergo to maximize its flight training opportunities.

Air Mobility Command has recognized the need for simulation to answer its training needs and has taken an aggressive role in utilizing aircraft simulation. Part of the impetus for this was a 1992 statement by General Ronald Fogleman: "I want to eliminate all non-revenue generating flying training" (AMC/DOTR, 1996). The push to eliminate non-revenue training has arisen from the decline in the DoD budget. The decreased threat to peace abroad has made defense budgets an easy target for reductions by lawmakers in Washington D.C.

The DoD budget in FY 1995 for simulation was $2,772 billion. Of this, $1,174 billion was set aside for aviation simulators (OSD, 1995: 7). This dollar amount equates to approximately 42 percent of the total simulation budget. The fact that there is such a large sum of money involved merits study on how we can best utilize simulation's capabilities. AMC's interest in this budget issue is how it can use money set aside for simulation to assist in extending aircraft service life and increase aircraft availability. We have the responsibility to provide the best training available within our financial constraints.

As one of AMC's core airlift aircraft, the C-141 has had a long and successful career. Because of airlift demands created during the Gulf War there was a higher than forecast operational tempo placed on the C-141. This pace resulted in an accelerated decrease in the life expectancy of the C-141. Many of the airlift missions flown by the C-141 were at emergency war operating weights (344,000 lbs vs. 325,000 lbs). These heavyweight operations, coupled with the high wartime utilization, have aged the C-141 well ahead of its programmed schedule. This aging process has led to flying restrictions being placed on the aircraft, restrictions which impacted training and operational capability. In January of 1994, AMC had only 43 of its over 200 C-141 aircraft available for use because of these flying restrictions. To meet training requirements, AMC restricted half of these 43 aircraft to conduct training missions exclusively (GAO, 1994: 9). Had the simulator capacity and fidelity been available at that time, much of the training could have been accomplished in the simulator. As AMC's airlift fleet becomes smaller, it cannot afford to find itself in this situation again. Air Mobility Command's ability to meet worldwide deployment commitments hinges on the prudent use of training resources.

The Strategic Airlift GAO report made three main responses to address the issue of AMC's aging airlift fleet. The first recommendation was that AMC increase its use of simulators to conduct flight training. It drew parallels with the commercial airline industry stating that it conducts 100 percent of its "pilot proficiency" training in simulators. The Federal Aviation Administration (FAA) and the airline industry cite cost-

effectiveness and safety as primary reasons for transferring flight training to the simulators (GAO, 1994:9).

The GAO recognizes that AMC is moving portions of its training to the simulator but says that it needs to do more. AMC leadership, however, has concerns over moving too many flight hours to the simulator. The concerns are based partly on the experience of the AMC pilots involved. The airlines use their simulators to conduct initial type rating training as well as annual proficiency training. Airline pilots typically receive a minimum of 80 aircraft flying hours a month conducting revenue-generating flights for the company. These flights are their primary means of maintaining proficiency. For this reason, proficiency conducted in the simulator is mainly for emergency procedure and crew resource management (CRM) training, the type of training that cannot be accomplished on revenue-generating flights. An airline pilot's sole job is to fly airplanes, while pilots in the Air Force have many duties associated with being a commissioned officer that do not allow them to fly nearly as much as an airline pilot.

Besides the actual aircraft flying time available to commercial pilots, the Air Force would face other concerns if it were to conduct a training program similar to the airlines. One of the main concerns is that of pilot experience. Newly-hired airline pilots typically have over 3000 hours of flying time. A new pilot from Air Force Undergraduate Pilot Training (UPT) has approximately 200 aircraft hours. The flight experience of commercial pilots may allow them to accomplish more training in the simulator. Most pilots will agree that simulators are beneficial, but nothing equates to the actual feel of the aircraft. No conclusive studies have been conducted on this experience issue for AMC to

draw from. Until AMC can find some supporting evidence, it will be hesitant to move too much of its training to the simulator.

A second recommendation from the Strategic Airlift GAO report dealt with the use of a companion trainer aircraft. This was a program that the Strategic Air Command (SAC) developed in 1976 (GAO, 1994:10). The program was carried over to AMC when it became a command in 1992. The program used small, inexpensive training aircraft, like the T-37, to provide a means for its pilots to obtain flight hours. These aircraft were much more economical to operate than were the large operational KC-135 and KC-10. This program worked well until the national defense alert commitment for AMC's tankers was eliminated. The aircraft that were previously unavailable because of alert commitments are now being utilized in other roles such as cargo and troop movements. These new missions provided more flying time to their pilots. While alert status was in effect, pilots averaged approximately 15 hours per month. Once alert was reduced, these pilots began to average over 30 hours per month. This increased flying time filled the hour shortage which the companion trainer program supplied. The increase in hours, coupled with the fact that it was becoming difficult for the pilots to maintain currency in both aircraft, resulted in program cancellation.

While the GAO logic for a companion trainer program was sound, it rapidly became dated when the national alert commitment was eliminated. AMC's operational commitment rate is high, and it cannot afford to tie up crews in another aircraft training system. Utilizing the currently available operational and training flying hours,

supplemented with simulator training, AMC does not need to adopt a companion trainer program.

The third suggestion by the GAO report is the increased use of commercial contract airlift. AMC recognizes that it does not possess enough organic airlift to meet its wartime requirements (AMMP-97, 1996). The Civil Reserve Air Fleet (CRAF) fills the gap for AMC's wartime requirement. While the C-141 was experiencing numerous flight restrictions, AMC relied heavily on the commercial sector to provide airlift. After these restrictions were lifted, AMC continued to utilize commercial airlift. In FY97, AMC plans to use over $700 million in contract airlift. AMC finds itself having more of a problem obtaining sufficient quantities of commercial airlift than it does finding enough business to contract out. Because of this capacity issue, AMC cannot really push more in this direction as a solution to the GAO report.

**Research Question**

With decreasing training budgets the military is forced to do more with less. AMC must examine ways to maximize flight training programs. The question for research is how can AMC more effectively use aircraft simulation and technology enhancements to improve it aircrew training?

**Investigative Questions**

Air Mobility Command recognizes the need to increase and optimize the use of aircraft simulation to meet its training needs. The purpose of this paper is to investigate where AMC stands with simulation and where it should be headed in the future.

The first investigative question is what is AMC currently doing with aircraft simulation? Areas to address this question include the benefits of simulation, simulator usage for training, and concerns over too much training with simulation. The next question is what are some of the training related costs associated with simulation? The cost discussion will include financial costs for upgrades as well as lost opportunities for training that can come from simulator usage. The third and final question is how can AMC benefit from new simulator technologies? New technology will affect the future of training and includes ideas such as simulator networking, unit training devices, and virtual reality.

The answers to these three questions should provide insight as to where AMC is and where it can go in the future for aircrew training.

## II. Training with Simulators

"Aircrew training is an absolute prerequisite for establishing and maintaining combat capability for AMC forces" (AMMP-97, 1996: 5-65). In an effort to provide the most cost effective training, AMC must constantly evaluate its current training strategies against new technology and ideas. AMC has an active master training plan that addresses its training needs. Following are four premises which guide AMC's training plan:

1. Technological advances will provide AMC with options to accomplish quality training in ground based trainers, freeing up aircraft to fly joint training and direct customer support.

2. Training devices should be common to all AMC weapons systems to the maximum extent possible.

3. Training devices must be upgraded simultaneously with the supported weapons system.

4. Any future training plans and programs must be validated with mobility customers and operators in order to meet future requirements. (AMMP-97, 1996: 5-65)

Using these four principles and evaluating their methods being used, AMC hopes to improve the quality of training it accomplishes with the use computers and simulation. Use of these devices will require fewer resources in terms of manpower, airframes, and actual dollars (AMMP-97, 1996: 5-81).

"Simulation has always been a difficult issue, tricky to analyze because it is surrounded by a semantic quagmire, and obscured by a miasma of emotion, over-claims, and flawed analyses, unilluminated by dependable statistics on costs or effectiveness" (Orlansky and others, 1994, I-1). A statement like this makes use of flight simulation

seem questionable. A long history of simulator success overrides any concerns brought about by Orlansky.

Air Mobility Command is actively using simulation to accomplish its training mission. AMC's current simulator inventory includes weapon system trainers (WSTs), part task trainers (PTTs), boom operator part task trainers (BOPTTs), and air refueling part task trainers (ARPTTs). These devices provide an excellent basis to "replicate aircraft systems' operations and instrument presentations throughout all phases of ground and flight operations" (AMMP-97, 1996: 5-82). A universally recognized benefit to simulator use is the ability to simulate events in a realistic environment at a fraction of the cost that real system training would incur. AMC has current initiatives to increase its simulator capabilities. Plans include enhanced motion and visual systems for the simulators. Upgrades such as these will allow more aircrew training to be accomplished in the simulator which reduces costs and increases the availability of aircraft for operational missions.

**Simulator Benefits**

Three basic benefits of using aircraft simulators are recognized in the literature (Henderson, 1984: 6; Orlansky, 1994: I-13,14; Rolfe, 1986: 1). They include safety, cost, and availability. The safety benefit is the most important. Training scenarios conducted in a simulator can be manipulated so that pilots can "practice responses to unlikely events, particularly those that could lead to disaster" (Haber, 1986: 96). Training which

includes unusual situations better prepares aircrews to handle unexpected situations that may occur during flight.

Simulators also provide a safe medium to experiment with new flying techniques. Most will recall the United Airlines DC-10 that crashed in an Iowa cornfield. The crew of this plane did a remarkable job of flying to get the aircraft on the ground in such a way that over half of the passengers survived. The emergency they experienced was one that the aircraft manufacturer had not considered and thus it was not in the training manuals. After the accident, simulator profiles were built based on how the pilots of that plane were able to handle the problem. Simulators provide the means necessary to safely educate and train aircrews to handle new situations such as this. The flexibility to adapt to changing training needs contributes directly to aviation safety.

A second benefit is that of cost. As mentioned previously, there is a substantial military budget outlay for flight simulators. The military recognizes the need to trim unnecessary costs. The operational cost of simulator training is a fraction of that for an actual aircraft. A 1977 report estimated that simulators cost 5 to 20 percent less to operate than aircraft (Orlansky, 1977). Studies have shown that skills learned in the simulator can be performed successfully in the aircraft. Being able to save flying time allowed the simulator procurement cost to be amortized in a few short years. We will need to capitalize on simulator training that is capable of meeting our training needs. Oil prices and decreasing budgets will force us to look for even more cost effective simulators to conduct training.

The third basic benefit is that of availability. As AMC's airlift assets continue to be tasked at a high utilization rate, fewer aircraft are available for local training flights. High utilization, coupled with the C-141 fleet retiring, is taking its toll on aircraft availability. The retiring C-141s are being replaced by the C-17 on an approximately two-for-one basis (two C-141s replaced with one C-17). This replacement amounts to only half as many aircraft being available. This reduced availability means that remaining aircraft are going to have even more demands placed on them, making it harder to set them aside for training missions. A simulator which is capable of performing the training tasks required will enable aircrews to receive their training without depending on the availability of an aircraft.

Simulators also allow a unit to conduct training during all hours, thereby not having to work around restrictions for airfield quiet hours. Simulators can also be used during weather conditions (except thunderstorms) that aircraft may not be able to fly in. The added availability of the simulator to conduct training is a benefit that cannot be surpassed in today's leaner training environment.

**Simulators in AMC**

Air Mobility Command has recognized the importance of simulator usage and has made it an integral part of its current training philosophy. Part of AMC's decision to conduct more training in the simulators stems from a 1982 Scientific Advisory Board recommendation. In its analysis, the board recommended that state-of-the-art training be utilized to make more effective use of simulation. It suggested that current simulators be replaced with state-of-the-art devices. Replacement would be based on a cost-benefit

analysis that would help to define simulator effectiveness. In replacing/refurbishing old simulators, the goal would be to attain simulator certification standards defined in the Federal Aviation Regulations (FARs), particularly Part 121 (AMC/DOTR, 1996). Airlines routinely use simulators under this regulation for nearly all their aircrew training, thus avoiding the need to use aircraft to conduct training. Since the airlines are capable of training like this it was determined that the military could also. The Board suggested that virtually all non-combat C-130 training be conducted in the simulator. It would have recommended other military aircraft also, but the C-130 was the only simulator system at the time that was capable of making the transition. Today, many systems are available to meet the varying spectrum of training needs.

The Department of Defense Inspector General (IG) has initiated an audit of "flight trainer acquisition, management and use within military departments" (Lieberman, 1996:1). This audit is an effort to follow up on key recommendations from the Strategic Airlift GAO report. The audit is fairly extensive, covering issues such as availability, acquisition, modification, utilization, proficiency, safety, and utilization to extend aircraft service life. AMC's aggressive simulator plan is addressing many of these issues.

The first question posed by the audit is AMC's position on using more simulator hours instead of aircraft flying hours. In answering this question, AMC is committed to the transfer of more training into its simulators. Much of the current simulator upgrades are being funded through money saved by not using aircraft to conduct training. AMC/DOTR reported that money saved over FY94-97 provided the "seed money" for upgrades to the C-5 and KC-135 simulators (AMC/DOTR, 1996). To save hours for the

seed money, AMC transferred approximately 32 percent of its C-5/C-141 pilot proficiency requirements to the simulator and 33 percent of the pilot air refueling training to the ARPTT. As C-141 and C-5 simulator upgrades are completed this fiscal year, the training transfer will be increased to 50 percent.

While these numbers show that AMC is committed to reducing flying time required for proficiency training, even more savings can be realized. With the new technologies coming on line in the C-17, AMC has a roadmap for future time transfers. The fidelity of the C-17 simulator allows pilots to accomplish 100 percent of their visual flight training, 80 percent of their instrument training, and 66 percent of their air refueling training (AMC/DOTR, 1996). These impressive numbers have made the C-17 simulator the standard for AMC's simulator upgrade program.

The programmed reduction in flying hours for the C-5 and C-141 is summarized in Tables 1 and 2. These tables provide the data that show that AMC is in fact moving its training from the aircraft to the simulator.

Table 1. C-141 Flying Hour Reductions

| | FY94 | FY95 | FY96 | FY97 | FY98 | FY99 | FY00 | FY01 |
|---|---|---|---|---|---|---|---|---|
| C-141 | 4513 | 4117 | 3657 | 3262 | 3756 | 3347 | 2523 | 1776 |
| Basic | 2608 | 2467 | 2184 | 1960 | 2326 | 2074 | 1571 | 1118 |
| A/R | 1905 | 1650 | 1463 | 1302 | 1430 | 1273 | 952 | 658 |

Table 2. C-5 Flying Hour Reductions

| | FY94 | FY95 | FY96 | FY97 | FY98 | FY99 | FY00 | FY01 |
|---|---|---|---|---|---|---|---|---|
| C-5 | 1738 | 1658 | 1647 | 1647 | 2409 | 2409 | 2409 | 2409 |
| Basic | 1077 | 1002 | 991 | 991 | 1501 | 1501 | 1501 | 1501 |
| A/R | 661 | 656 | 656 | 656 | 908 | 908 | 908 | 908 |

These tables specifically describe the savings for two of AMC's five major aircraft systems. As AMC completes its programmed simulator upgrades it will see further flying hour savings. These are summarized as follows:

FY98: 2% of C-141 total hours--18% of the training hours

FY98: 3% of C-5 total hours--29% of the training hours

FY01: 20% of KC-10 total O & M hours

FY02: 22% of KC-135 total O & M hours

It is readily apparent from these numbers that AMC is shifting more flight training to the simulator. AMC is doing its part to comply with the recommendations of the Strategic Airlift GAO report.

**Training Concerns**

A key concern within AMC is how much training should be shifted from the aircraft to the simulator. Currently AMC is aiming to accomplish 50% of its proficiency training in the simulator. The concern is that too much training accomplished in the simulator may affect the proficiency of the aircrews in the aircraft. No definitive studies

show how much flying can be transferred to the simulator; anecdotal information from the airline industry and AMC's own experience with simulators is all there is to draw from (AMC/DOT, 1995). This lack of information suggests that this would be a good area for further study.

One method to address this transfer concern would be to base the amount of pilot simulator proficiency hours on the pilots actual aircraft flying experience. In other words, the more aircraft hours a pilot has, the more proficiency training he or she can accomplish in the simulator. A system such as this should allow AMC to maximize its use of simulator training time while allowing less experienced pilots to obtain valuable aircraft flying time.

In making the determination of how much simulator training to assign, AMC could use the flying currency training levels already established in command guidelines. These training levels are assigned each semiannual period by the aircrew member's commander and are based on experience and aircraft proficiency (MCI 10-202, 1995: 20). This system allows for different levels to be assigned for different qualifications in the aircraft. Training levels range from "A" for highly experienced crewmembers to "D" for basic qualification. The level a crewmember is assigned then determines the actual requirements for a set of training events. For example, a level D pilot has a semiannual requirement for 30 takeoffs, while a level A pilot is required to accomplish only 12 in the same period (MCI 10-202, 1995: 31). Limiting the hours a crewmember could utilize the simulator to accomplish proficiency training against established training levels could

allow for the proper transfer of training. Further study in this area is needed, however, to determine the effectiveness.

Simulators play an important part in AMC's training programs. The benefits of simulator usage are well documented. AMC is transferring more of it training for the aircraft to the simulator as the capability increases. This transfer is making more aircraft available for operational taskings. The training transfer, however, is not without cost. The next chapter will address some of costs associated with simulator training.

## III. Training Related Costs

As mentioned in Chapter One, a substantial sum of money is set aside in the DoD budget for aviation simulation. In planning for future budgets it will be important to understand and know the costs of obtaining and utilizing simulators. This chapter addresses some of the issues involved with purchasing and upgrading simulators. It also addresses some of the costs in which dollar amounts are difficult to determine, such as lost opportunities for training.

A common question that arises when contemplating a new training system is the cost. Training is a cost that is not exclusive to the military. Civilian businesses recognize the need for training. They plan and budget for it:

> Corporate training and development is estimated to be a $30 billion industry. That accounts only for formal structured education, and does not include the $180 billion estimated to be spent on informal, on-the-job training. This amount is almost as much as the total budgets of all publicly financed colleges and universities in the United States. (Carnevale, 1986: 18)

In today's competitive economy, a business cannot remain successful if it does not keep its people trained. AMC depends heavily on training to provide mission-ready crews and support forces that are current and qualified to accomplish mission tasks and other related activities (AMMP-97, 1996: 1-16). Because of this reliance, military budgets are heavily weighted with training expenditures. In fact, training is one of the largest consumers of Air Force funds (SAB, 1997).

For AMC, the budgetary focus for its simulators is on upgrades versus new simulator system acquisition. AMC has simulator systems for the aircraft that are in the current inventory. All of these training systems are undergoing upgrades or are in need of

upgrades with the exception of the C-17 simulator. These upgrades primarily include technology updates that will improve the training effectiveness of each system.

### Upgrade Costs

The acquisition cost for a new simulator can be cost prohibitive in today's training budget environment. For example, one full-motion dome F-16 simulator costs approximately $20 million (Grimes, 1995: 29). Upgrading existing simulators is a more economical option. By upgrading its existing infrastructure of simulators, AMC will maximize its investment in simulator training.

The AMC simulator upgrades are based on industry standards set by the Federal Aviation Administration (FAA). They are the same standards upon which the airlines base their simulator capabilities. The majority of the airlines are using FAA level-C standard simulators. Level-C provides an accurate aircraft systems representation, functional switches for the aircraft systems, full-scale cockpit replica, control forces for aircraft type, night/dusk visual system and a motion system with six degrees of freedom. Level-C simulators enable training accomplished in the simulator to be substituted for actual aircraft training time. Less time training in the aircraft means savings in the training budget, since a simulator is more economical to run than an aircraft. AMC is using FAA level-C as its standard and adding a few visual enhancements. These training enhancements include a full-color day/dusk/night visual system, wide-angle field of view, and cross-cockpit viewing (AMC/DOTR, 1996). These upgrades allow AMC to increase transfer of the actual aircraft training to the simulator as discussed in chapter one.

The reason for the upgrades versus new simulator acquisition is cost. For example, bringing the C-141 simulator system to the enhanced FAA level-C will cost approximately $54 million and will cover upgrades for seven simulators. It is estimated that the C-141 simulator upgrade alone will save $10 million per year as training is transferred from the aircraft to the upgraded simulator (AMC/DOTR, 1996). This investment amounts to less than $8 million in upgrade costs per simulator, which is much more economical than a new simulator purchase.

The C-5, KC-10, and KC-135 simulator upgrades are also on track. The C-5 simulator upgrades have a cost estimate of $64 million on seven simulators with an expected savings of $17 million per year. The KC-10 also has a $64 million price tag but for only four simulators and is estimated to save $6 million per year. The fourth simulator system for upgrade is the KC-135. The cost for the KC-135 upgrade is the largest, estimated to cost $184 million and affect 18 simulators, with an estimated savings of approximately $12 million per year (AMC/DOTR, 1996).

The projected savings from these upgrades will be the result of a more capable simulator system that will allow for an increase of flight training hours to be transferred from the aircraft to the simulator. This transfer not only saves money from the training budget, but it also frees additional aircraft for operational missions. Not having the aircraft committed for training allows it to be available for operational mission taskings. Availability of aircraft for the airlift customer is a hard quantity to define with a dollar amount, but if the customer has more aircraft available to meet its airlift needs, satisfaction will be higher.

**Maintenance Costs**

It is a simple fact that if you fly an airplane less, it will cost less to maintain that aircraft. While AMC is saving money by transferring flying training into simulators, its aircraft are being utilized for other missions. Because of the limited number of aircraft in the inventory and the increasing demand being placed on those aircraft, AMC may not realize any cost savings from a maintenance standpoint. Flying hours are being reduced from the training side, but these hours may now be flown as operational mission time. The cost associated here is beyond the scope of this paper and should be further addressed to gain a true cost-benefit analysis.

In setting up a maintenance cost analysis one should look at aircraft wear issues. An aircraft that flies ten hours on a transoceanic flight will normally not experience the same type of wear that the same aircraft would by flying ten hours of transition work in the local flying pattern. Local pattern work will create significantly more wear on items such as tires, brakes, and landing gear. If one can quantify the increased wear on these and other items when flying transitions, it should show that flying less in the local pattern means less wear on the aircraft and thus decreased maintenance costs.

Another maintenance cost that is even harder to quantify is the cost of lost training opportunities. Often when we discuss the use of simulators it is in relation to aircrew training. By having simulators with more capabilities, less local training aircraft will be required to meet aircrew training needs. Maintenance personnel rely heavily on the availability of aircraft to perform their training. The benefit of having aircraft in the local pattern is that they provide a continuous source of unscheduled maintenance opportunities

for maintenance. If an aircraft is flying an off-station mission and a system breaks, the maintenance personnel in the enroute system will receive the training opportunity to repair it instead of the home station personnel.

This maintenance training dilemma is an example of suboptimization. By optimizing the efficiency of using more simulators for aircrew training, an undefined loss of training is taking place for the maintenance personnel. AMC should further study this area to determine the effect of lost training opportunities in maintenance. If AMC does not keep its maintenance force fully trained, the reliability of its aircraft will decrease and will negatively affect its ability to perform its mission.

### Contracting Costs

Many of the functions in today's military are being contracted out. The continued reduction of budgets is forcing the military to use contractors to cut costs. Aircraft maintenance is an area that is being pushed towards outsourcing. These contracts appear to save money on the surface, but problems can arise when contractors fail to provide the services promised.

A current maintenance contract problem is occurring at AMC's primary training base (Altus). This contracting problem is directly affecting the training of AMC aircrews. In short, the maintenance contract is failing to provide the number of aircraft per day for flight training as specified in the contract. This failure means that aircrews that are at Altus for training are not receiving the scheduled training because of a lack of available aircraft. The aircraft utilization rate specified in the contract was approximately 63 hours per month if 11 aircraft were assigned to the base. This utilization rate decreases if more

aircraft are assigned to Altus. Because of the contract failure, the renegotiated utilization rate will be approximately 49 hours per month with 11 aircraft (Smith, 1997). The difference means a loss of 14 hours of training per aircraft per month. This loss has resulted in incompletely trained aircrew members being sent back to their bases. This has a tremendous cost to AMC's readiness posture since the main pipeline for aircrew training has shrunk.

The situation at Altus might be alleviated with an increased use of upgraded simulators. At Altus, the C-17 initial pilot training course conducts the majority of its training in the simulator and the student receives only two aircraft sorties, one of which is the evaluation. In contrast, an initial C-141 pilot receives simulator training and five aircraft sorties, including the evaluation. If the C-141 system could provide the same capability as the C-17, a similar training profile should be possible. The reduced reliance on aircraft to conduct training could ease the problem of the failed maintenance contract and should be further studied a method to reduce usage of aircraft for training.

Keeping personnel trained is an expensive process. To help minimize training costs, AMC is utilizing a robust simulator upgrade plan. Upgrades are more economical than new purchases. Upgrades also build upon existing infrastructure. There will be lost training opportunities associated with increased use of simulation. Lost opportunities are hard to quantify in terms of dollars. New technology holds the promise of further cost savings and a reduction in lost training opportunities.

## IV. Future Enhancements

The utility of simulators in commercial airline operations has been demonstrated to be profoundly effective in increasing pilot performance while reducing aircraft training hours (SAB, 1996: 7.2-1). The same effectiveness holds true for the DoD and AMC. Simulators for transport aircraft use well known technology which is fairly straightforward. AMC and the Air Force need to look beyond the standard simulator systems for new ways to enhance the training arena.

Air Combat Command (ACC) recently held a conference in which approximately 230 aviation and military representatives exchanged ideas, briefings and open discussions on simulator technology (Proctor, 1997: 1). The conference, which was called "Industry Day," came about as a result of ACC Commander General Hawley's desire to exploit technology for flight simulator training. This chapter discusses some possible options through which AMC and the Air Force could enhance aircrew training conducted in its simulators.

### Networking Simulators

In discussing simulator networks, General Hawley said, "Most of today's simulators are designed to train a single crew on aircraft systems and procedures, but we fall short in replicating the complex environments aircrews face in real contingencies where they must function as part of a well integrated joint team" (Proctor, 1997: 1). It is critical that AMC fully integrate its aircrew training into joint training.

> Joint training reinforces joint doctrine and offers a common ground from which to plan and operate. It creates opportunities where interoperability issues can be addressed, resolved, and ultimately implemented in a plan where each service's capabilities complement one another. The objective is to instill jointness as an irreversible trend in military affairs. (USJCS, 1994: 1)

Many of the missions being conducted today by AMC aircrews are in this type of joint arena. Operations in the Bosnian theater are an example. As AMC operates with other services and its own units, it is critical that each service understands how it fits into the overall plan. This understanding comes through both written doctrine and large scale exercises in which the units train together. Both of these methods have drawbacks. Written doctrine is subject to the reader's interpretation, and with many readers, there can be many opinions. Training exercises are extremely expensive and time consuming. As a result of high operational commitments and decreased budgets, planned exercises are often canceled. A possible way to combat the latter problem is with the use of networked or linked simulators. Industry refers to this concept as "distributed interactive simulation" and it will tie different types of simulators in a variety of locations together for integrated, joint service training (Grimes, 1995: 28).

The ability to link different simulators together will enable personnel from various locations and from different services to conduct joint training exercises. This ability will let the services assemble large numbers of trainees via simulation. This ability is safer and less time-consuming than committing personnel and equipment into the battlefield (Grimes, 1995: 28). The linking together of simulators is being moved along with the standardization of databases used in those simulators. Standardization decreases costs and improves effectiveness, since the services can reuse all the databases that have been

built over a long period of time for all types of weapon systems. Industry analysts view distributed interactive simulation and its common databases as the "glue" for this new type of training (Grimes, 1995: 28). To make this type of training available to more users, lower priced simulator systems are key. One of those systems is the unit training device (UTD). The price tag on the UTD makes it the perfect match to use this "glue" and build a training system that will fulfill today's demanding training needs.

The discussion so far has been in relation to joint training opportunities with the other services. AMC can draw upon these opportunities and use the integration concept within its own simulator force. The ability to link airlift training from one base with air refueling training from another will provide an invaluable arena in which to train. Linking with other bases in AMC during training would allow a transfer of ideas and operating techniques which would increase the interoperability of crews within the command.

This type of interaction would be most beneficial for airdrop and air refueling training because of the multi-ship formations that are typically involved. Currently, this type of multi-ship training with other bases is limited to Joint Airborne Air Transportability Training (JAATT) missions conducted with other services. The ability to conduct more of this JAATT type training through the use of simulators will increase the effectiveness of live training in the aircraft.

**Aircrew Training Enhancements**

As mentioned previously, when discussing simulator training it is often biased towards pilots. This is acceptable if one is concerned with training in a single-seat fighter

type aircraft. Since all of AMC's aircraft require multi-position crews to operate, it is important to look at new and enhanced training for all crew positions.

With the exception of the C-17 simulator, AMC does not have a system that incorporates the loadmaster position. Loadmasters are an integral part of any airlift aircraft and their training should be incorporated with the simulator training conducted for the rest of the crew. The C-17 simulator uses loadmaster stations to train student loadmasters in normal, abnormal, and emergency procedures. The loadmaster interfaces with the host computer and the aircraft avionics mission computer. The loadmaster station has the capability to integrate with the simulator or operate independently of the simulator (Slish, 1994: 33).

The ability to interact with the full crew provides valuable learning opportunities for the loadmaster student as well as for the rest of the crew. It is important for aircrews to be able to work together to accomplish the mission safely. Crew resource management (CRM) is an area of training that addresses this interaction exclusively. Linking the loadmaster to the training scenario contributes to the CRM learning process. Better CRM among aircrews leads to increased efficiency and safety. These benefits help to provide the best trained aircrews to meet the airlift challenge.

Similar to the loadmaster on an airlift aircraft is the boom operator on a tanker aircraft. Boom operators have simulator devices in which they conduct training specific to their refueling duties. The problem again arises as to how to integrate them with the rest of the aircrew. An interactive system such as that utilized for the C-17 simulator system should be studied for AMC's boom operators as well as loadmasters.

## Unit Training Devices

The discussion of integrated systems included mention of unit training devices (UTD). A UTD is a stand-alone simulation system that is designed to fit in an office type setting. These systems are considered low-cost but offer high fidelity. The UTD systems are able to bring high-end simulation down to the unit level (Grimes, 1995: 28). Having the UTD systems at the unit level allows more access by more crewmembers. These devices will take simulator training into a new era of military pilot training (Pietrucha, 1996: 1).

The concept of using UTDs is another idea coming from the fighter aircraft community. The intention is to provide a platform from which to provide new student, transition, and continuation training for F-15 and F-16 squadrons (Grimes, 1995: 28). The cost of a UTD is only a fraction of that of a full motion simulator. Estimates for either an F-16 or F-15 UTD are $700,000 a copy versus $20 million for a full-motion dome simulator (Grimes, 1995: 29). This low price makes it affordable at the unit level.

Currently the F-15 and F-16 systems are being utilized to practice emergency procedures, flight instrumentation, air-to-air and air-to-ground combat, and tactical maneuvering in a threat environment (Pietrucha, 1996: 1). The uniqueness of the system is that it is stationary and does not require hydraulic systems to operate. The units are small enough to fit into an office environment and thus don't require their own facility to support them. Their size also allows for the UTD to be deployed with the squadron. This deployability provides a tremendous training resource for the squadron when it is deployed from its home station. With fighter deployments frequent in today's Air Force,

the ability to train with a simulator and maintain currency while on the road is a key benefit of the UTD.

With the UTD technology already utilized, AMC needs to further study how it can apply and benefit from its application. As AMC transfers more and more training to its existing simulators, there will come a point at which there is no longer any capacity to continue the transfer. When the existing capacity is reached the only recourse currently available is to purchase more simulators. This is a costly option and may be avoided with the adoption of UTDs. A UTD may not be able to support all the training requirements that AMC needs, but by transferring compatible training events from the full-motion simulators to the UTDs, an increase in capacity will become available in the full-motion simulators to handle AMCs training needs.

**Virtual Reality**

Virtual reality has become a common phrase in today's video game industry. The Air Force is also using the term and its technology in the development of new training systems. Some of the latest ideas are coming out of the Joint Strike Fighter (JSF) program. With the JSF in the development stages there is an opportunity to incorporate new concepts such as virtual reality.

The JSF development team expects to utilize virtual reality with a helmet-mounted display. Information will be able to be displayed on the helmet's visor and will be integrated with a series of surrounding display panels which will show the simulated battlefield. The helmet will also have the possibility of interactive gloves that will aid the pilot in quickly learning aircraft "switchology" (Fulghum, 1996: 101). Learning switch

position and functions is not a large concern for AMC's aircrews. Due to the age of AMC's fleet, most of the aircraft have relatively straightforward switchology and training is thus relatively simple. The C-17 and its complex computer systems may benefit from the interactive glove technology.

Another concept from the JSF is maintenance personnel training. AMC can benefit through the application of virtual reality for maintenance training. JSF planners envision using helmet-mounted displays for maintenance personnel. The helmets will have low-cost computer packs to supply maintenance instructions on a need-to-know basis and a 3-D projection of the aircraft that can be worked on as if they were a real aircraft (Fulghum, 1996: 101). This type of capability would allow maintenance personnel to train without having an aircraft to train on, a problem which was discussed in Chapter Three. Industry expects linkages through the helmets will allow the image to be transmitted to other observers at different locations for training opportunities and troubleshooting discussions (Fulghum, 1996: 101).

Virtual reality may be a possible solution to the problem of the loadmaster and boom operators not being linked into AMC's current simulator training. Building upon existing virtual reality technology, designers may be able to engineer a helmet and glove type of system that will tie the loadmaster and boom operator in with the rest of their crews. The interaction will increase the efficiency of the aircrew to handle the various mission scenarios it may encounter.

## V. Summary

It is common knowledge that the United States Military is the best trained military force in the world. The Pentagon invests extensive funds to train its personnel. When not engaged in military operations, the mission of the Department of Defense is to maintain its overall readiness through training exercises. For this reason, the military is continuously attempting to improve training methods (Medin, 1997: 36). Regarding training, General Douglas MacArthur said: "In no other profession are the penalties for employing untrained personnel so appalling or so irrevocable as in the military" (USJCS, 1994: 1). Air Mobility Command is searching for new ways to better implement its training resources to meet today's challenging training needs.

In an effort to meet its constant aircrew training needs, AMC is actively using aircraft simulation. Use of simulation provides the benefits of safety, reduced cost, and increased training resource availability. Simulation is also addressing the findings from the GAO Strategic Airlift report. The ability to transfer aircrew training from the aircraft to the simulator is freeing AMC aircraft to perform operational missions for its customers. As AMC's fleet decreases in numbers, it is important that they still meet their customer's airlift needs. Aircrew training with simulators is doing just that. AMC must, however, continue to monitor the transfer of training to its simulators to determine if there are any adverse effect to the training received by its aircrews.

As with any training program, there are associated costs. In AMC, the majority of simulator costs come through simulator upgrades. These upgrade costs have a payback

schedule that is realized through the transfer of aircraft flight time to simulator flight time. The money saved by this transfer will pay for the upgrades. Another associated cost to AMC is the lost training opportunities for its maintenance personnel. As aircraft spend more time in the worldwide system and less time in the local flying pattern, the platforms are not available for AMC's homestation maintenance personnel for training. A third cost concern is that of contract problems. As the Air Force and AMC moves towards privatization, contract disputes and failures can and are affecting aircrew training.

Air Mobility Command also needs to continue its thinking "outside of the box" when it comes to new training concepts and ideas. The major simulator focus at present is to upgrade its current infrastructure. New ideas such as the networking of different base simulator systems will provide enhanced training capabilities for its users. The ability to train an entire aircrew together will enhance AMC's simulator training. The current system of loadmaster and boom operators training on their own non-integrated systems is a detriment to training. Utilizing the C-17 loadmaster integration system may be a way to combat the deficiency. Another area for the future is capacity constraints. New simulator systems such as UTDs are needed to provide the capacity to transfer more aircrew training into the simulator. Today's budgets do not allow for the acquisition of new full-motion simulators for the older aircraft that comprise the majority of AMC's fleet. Virtual reality is yet another concept that needs to be further evaluated for applicability in AMC's training. Virtual reality may provide the answers to integrating both the loadmaster and the boom operators into existing simulator systems. AMC

maintenance personnel may also reap the benefits of virtual reality similar to those being seen in the JSF program. The National Training Systems Association study titled "Training 2000," identifies a number of trends for the Department of Defense. Some of these trends include a shift in emphasis from large-scale proprietary simulators to deployable, reconfigurable, non-proprietary simulators; increasing the use of networked simulator systems; more joint service simulations; and a shifting from large, specially developed training systems toward nondevelopmental, commercial off-the-shelf training hardware and software (Nordwall, 1996: 95).

This paper is a brief look at how AMC can benefit from new trends in training. The ability to exploit today's increasing technology will ensure the future readiness of AMC's aircrews. It is this readiness that the DoD depends upon to project its forces worldwide.

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## Vita

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This research paper examines AMC's status regarding simulator training for its aircrews. AMC is increasing its use of simulators to conduct aircrew training. Upgraded equipment is allowing for an increased transfer of training from the aircraft to the simulator. Costs in doing this training are being amortized through savings in aircraft flight training time. New technology is providing ways to enhance both aircrew and maintenance personnel training in the future. This new technology includes virtual reality, simulator networking, and unit training devices. AMC must continue to look beyond the standard simulator training programs for new ways to meet its training demands.

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**Effective Use of Aircraft Simulation in Aircrew Training**

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